STUDY ON THE POTENTIAL OF GREYWATER REUSE/RECYCLING IN INDIVIDUAL HOUSEHOLD SYSTEM

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CHAPTER 1

1.0 INTRODUCTION

Greywater is the output from bathtubs, showers, sinks, floor drains and washing machines, which although no longer clean, it is not as contaminated as toilet water. This water can be relatively easily treated on-site for reuse in non-potable contexts such as toilet flushing and garden irrigation. Studies in other countries have estimated that the usable domestic greywater resource easily could amount to 35 percent of the total domestic demand. Relatively clean greywater is also produced by non-domestic establishments such as restaurants, hotels, schools, and other public buildings.

By intercepting greywater before it goes to the septic tank or the municipal wastewater system, and providing some treatment (in certain cases, no treatment may be required) the water may be reused to irrigate plants. With a little additional treatment, the water also may be used for toilet flushing. Some safeguards are required and provided care is taken as to what enters the greywater in the first place, and the risks to human and plant health are minimized. Reuse is simpler than many people assume.

Greywater reuse is being increasingly widely practiced in other countries, where water is scarce, and often occurs whether legal or not. The technical means of providing safe ways to reuse graywater, and the issues associated with health and environment have been examined in detail by a number of authorities in other countries. Greywater reuse in Malaysia is not widely applied. Greywater reuse is very important to control water pollution as the population in Malaysia has increase so the water demand also will increase in the future. It is likely that practical, safe ways to reuse graywater can be developed and promoted in Malaysia.

This report will identify the application of greywater reuse in sustainable water management in Malaysia.

1.2 PROBLEMS STATEMENT

Eventhough Malaysia has been blessed with abundant supply of water resources, the authorities, industries and the society should not take for granted that there will always be sufficient supply to meet the demand. The problem of water pollution is now becoming more serious with reports indicating a downward trend of about 1 percent per annum in river water quality. Sewage water pollution account for about 79 percent of the pollution source, while industrial and agricultural pollution account for 8 percent and 13 percent respectively (Suhaimi, *et.al.*, 2002).

A need for paradigm shift is necessary to ensure optimum utilization of resources. This is now a movement for a return to reuse and recycling the resources. This implication of alternative is really beneficial for future recycling scenarios on Malaysia's water resources and environment. This report presents a several indication of the potential of greywater reuse application in domestic houses in Malaysia.

If the water pollution did not controlled, there will be clean water supply shortage in the future. This problem will effect on the water supply in Malaysia and and directly can cause health problems to the residence.

1.3 RESEARCH OBJECTIVES

The objectives of the study are:

1.1 To study the variation of quantity and quality of greywater from a residential area

1.2 To evaluate the potential of greywater reuse/recycling practiced in household system in Malaysia

1.3 To establish appropriate technology to implement the grey water reuse/recycling in Malaysia.

The above objectives have been studied through several experiments and monitoring at case studies, which are elaborated in the following chapters.

Chapter 2 is a review of the current literature, describing major environmental problems when reusing greywater.

Chapter 3 gives the results of a monitoring campaign which investigated the variability of greywater quality from four different houses, the effects on the soil and plants, and leachate collection using lysimeter. This chapter attemps to answer with some certainty the following questions:

Are the variety of chemicals, preferences of householders and greywater maintenance systems reflected in the chemical quality of greywater, are the chemicals harmful to plants, and do they build up in the soil as a result of greywater irrigation?

Chapter 4 is a further investigation of surfactant componds, which are usually found in laundry and soap products on soil hydraulic conductivity.

Chapter 5 is a general conclusion on the potential of using greywater on mainly for irrigation.

CHAPTER 2

A REVIEW ON ENVIRONMENTAL HEALTH RISK ASSESSMENT FOR GREYWATER REUSE IN HOUSES

Abstract

Greywater is composed of variable quantities of components of wastewater which may come from the shower, bath tub, spa bath, hand basin, laundry tub, clothes washing machine, kitchen sink and dishwasher except toilet waste. The purpose of this study is to review of any potential environmental and health risk assessment from greywater reuse application in individual household system. This study drives to apply the greywater reuse for future application in Malaysia. The review starts by understanding the study base, identifying the problem, and determining the goals and objectives of the study, reviewing exploration, review analysis and eventually, suggestion has been made for future practice in Malaysia. From the review analysis, different methods were used to identify hazardous matter and its risk assessment. The existing study is not exactly applicable in our country since factors influenced such as demographic, culture habit and geographic condition drive to unique characteristics of greywater in Malaysia. The system needs to be modified from the conventional method with the added of the disinfection process. From the study, it may contribute the knowledge of risk assessment from potential hazardous problems resulted from greywater reuse. This strategy is essential to present confident and safety level among public of greywater reuse in Malaysia.

Keyword : Greywater, risk assessment, hazardous, review

2.0 INTRODUCTION

In all over the world, there are many communities and individuals already practice greywater reuse. Some people reuse greywater wisely but many reuse greywater poorly such as by bucketing bath water to the garden or diverting laundry washing machine water directly to a lawn where children and pets may be exposed to the greywater. The reuse of greywater especially in domestics use is necessary and become increasingly common because it is now practicable for water conservation. Reuse is often practiced without a clear understanding of the public and private health risks and the environmental degradation that may be caused without properly designed land application systems for dispersal of greywater. Therefore there is need to has an environmental health risk assessment to measure the risk's quality.

Even though Malaysia is rich in water resources; the consciousness level of Malaysians about greywater reuse and its application is still low. Most of Malaysians do not know that the greywater can be reused and applied for non-potable use. The reuse of greywater is being increasingly practiced in a number of countries whose water crisis is less critical. Individual system for household water use is affected not only by water conservation equipment, like low flow showerheads, but also by personal habitual actions, like the amount of time spent in the shower or letting flowing tap water go to waste while using soap to wash dishes, washing car, brushing teeth, washing vegetable and so on. All these activities can cause waste of water.

There are many countries have carried out greywater reuse practices and investigated the technical means of reuse as well as the health and environmental implications. However in Malaysia, there is no national guideline for greywater since this concept is inexperienced. Indeed, greywater reuse is an alternative way to reduce water pollution since Malaysia's population has increased; as a result the water demand also will increase in the future. It is likely practical, safe ways to reuse greywater can be developed and promoted for future application. Hopefully, this effort can assist water management agencies, government and the public to recognize the benefits of greywater reuse.

2.1 LITERATURE REVIEW

2.1.1 What is Grey Water?

Apart from toilet wastewater, the term greywater is used when designating all the wastewater produced in a household. Sullage, grey wastewater and light wastewater are terms also used. Grey water is wastewater from baths, showers, hand basins, washing machines and dishwashers, laundries and kitchen sinks; except toilet waste **[1,2]**. Although some authors exclude wastewater originating from kitchen sinks given its high content of oil and food particles **[3]**, this document also classified as it as grey water, but clearly indicates that grey water from kitchen sinks requires special attention. Since greywater is a reflection of household activities, its main characteristics strongly depend on factors such as cultural habits, living standard, household demography and type of household chemicals used.

2.1.2 Water Issues in Malaysia

Malaysia is rich in water resources, its development has been the basis for the socio-economic development of the country over the past decades. Lately, the water supply situation for the country has changed from one of relative abundance to one of scarcity. Population growth and urbanization, industrialization and the expansion of irrigated agriculture are imposing rapidly increasing demands and pressure on water resources, besides contributing to the rising water pollution. The way forward to prosperous and sustainable future is to keep development to a level that is within the carrying capacity of the river basin while protecting and restoring the environment.

Even tough Malaysia has been blessed with abundant supply of water resources, the authorities, industries and the society should not take for granted that there will always be sufficient supply to meet the demand. The problem of water pollution is now becoming more serious with reports indicating a downward trend of about 1% per annum in river water quality. **Sewage or wastewater water pollution accounts for about 79% of the pollution source,** while industrial and agricultural pollution accounts for 8% and 13% respectively **[4]**.

Malaysia has more than 150 river systems that contribute 98% of the total national water use, whilst the remaining is contributed by groundwater. To secure safe yield from surface water sources, 55 single purpose and 17 multipurpose dams were constructed, with a total storage of 30 billion m^3 **[5]**. Water supply systems that are too dependent on surface water sources are at the mercy of the weather.

This paradigm is inadequate for sustainable water management. A need for a paradigm shift is necessary to ensure optimum utilization of resources. This is now a movement for a return to reuse or recycling of household systems. This implication of alternative is really beneficial for future recycling scenarios on Malaysia's water resources and the environment.

2.1.3 Water Use in Malaysia

Malaysia is a good example where solely Financing Water Supply Management is increasingly unworkable because despite being blessed with abundant rainfall (3000 mm/year), water problems are increasing and pose a serious threat to people and the economy. Non-revenue water (NRW) level in Malaysia at 39 per cent is way too high. In some states, it is as high as 60 per cent. For instance, if 20 per cent of the NRW could be saved, this enough to fill 67 dams, each the size of Teluk Bahang Dam [6].

Many of Malaysians only use the tap water as their major water resource particularly in urban area. Fresh water supply is used for laundry, food and drinking, bathing, watering plant, flushing toilet and more various basic needs in diurnal life. However, most people in the villages or rural areas practise individual system. They more practice used water recycling. For instance, rain water usage. Houses in rural areas mostly have a special barrel for rain water storage. This water is used as a second water resource for watering plant and other uses. Likewise, rice water wash also is sometimes reused for watering plant. In fact, this way of life would be able to save a lot of water resources.

Table 2.1 shows the estimated water usage for daily use in Malaysia. It can be seen that the highest usage of water is for watering the lawn and yard, secondly is for washing cars and the lowest usage is for drinking. Thus, by practicing the water reuse, it can reduce lots of water consumption by reducing usage of fresh water for these activities.

Table 2.1: Estimate Daily Water Use in Malaysia [6]

Activities	Estimated Water Usage for Daily Use (Litres)
Bath or Shower	50-100
Lawn and Yard Watering	700
Dishes Washing by Machine/Hand	50-200
Clothes Washing	200
Car Washing	400
Teeth Brushing	4
Cooking	40
Drinking	2
Toilet Flushing (once)	15-25

2.1.4 Comparison of Malaysia and Other Countries in Water Management

Compared to many other countries, the price of clean water in Malaysia is relatively very low to the extent that people take it for granted. **Table 2.2** indicates the water tariff in several countries. It reveals that Malaysia ranks the lowest in water tariff of US$ 0.0947 per m^3 compared to Hong Kong, Dubai, Singapore and other countries. Energy, Water and Communications Minister Datuk Seri Dr. Lim Keng Yaik complained that **"Malaysians use water three times more than consumers in Britain and twice more than those in Singapore and Cambodia."** [7]. In fact, the price of water is lower than the cost of treating and piping it to customers. This is because water is a resource that is heavily subsidized by the Government. Based on the current water rates for domestic consumers in Penang, Malaysia the breakdown cost of water is: 22 cents per litre for the first 20, 000 litres; 42 cents per litre for the subsequent 20,001 to 40,000 litres; 90 cents per litre from 60,000 to 200,000 litres; and RM 1 per litre for 200,000 litres and beyond (The Star, 26 April 2004). In Malaysia, the price of water is so low that nobody makes any effort to save it. Moreover, local decision makers, especially where rainfall is abundant like Malaysia, do not consider water reuse as an option when considering water resources alternatives.

Table 2.2: Water Tariff Average in Some Countries in 2005 [6]

Location	Water Tariff (US$ /m^3)
Hong Kong	0.92
Dubai	0.8985
Singapore	0.62
Australia	0.60
Texas, USA	0.5947
Tennessee Water Authority	0.5262 - 0.8603
Manila (Based on Average between Manila Water and Manila Rates 2005)	0.45
Malawi	0.30
Indonesia	0.2105
Malaysia	**0.0947**
India	0.037

2.1.5 International Experience on Greywater Reuse

Water reuse is a growing practice in many regions of the world, including countries that are not typically considered to have problems with water scarcity. In the US, practice of recycling/reclaiming water is large and a growing industry. An estimated 2.6 billion gallons per day (bgd) (9.8 gL/d) of greywater are reused in the US. for applications ranging from the irrigation of golf courses and individual lawns to edible crop irrigation, various types of industrial reuse, and indirect potable reuse, such as groundwater recharge.

On the global scene, Japan, the US and Australia maintain the highest profile in greywater reuse [8]. Other countries involved in active greywater research and applications include Canada, UK, Germany and Sweden [9]. On the regulatory and legal arena, greywater reuse has gained a degree of acceptance in the US and Australia. At the regional level, Saudi Arabia, Cyprus, and Jordan have introduced greywater systems to optimize water use.

It should be noted that each country has a different reason for the adoption of greywater reuse. For example, the Japanese reuse initiative is driven by the demands of a high population density and small land space, while the US, Australian, Saudi Arabian and Jordanian initiatives are a direct response to drought conditions and the unregulated uptake of domestic GW reuse for garden irrigation. However, it seems that certain greywater reuse initiatives are not focused

directly upon attaining a more sustainable future; rather they are short-term reactions to water scarcity.

The main use for greywater in Germany is for toilet flushing, irrigation and garden plants. In terms of treatment of GW, some manufacturers of greywater systems assume a mechanical treatment of the greywater to be satisfactory **[10]**, whereas others claim a more advanced treatment technology to be necessary. GW recycling plants have proved their efficiency and applicability in practice for almost 10 years.

In Tokyo, Japan, the reuse of treated wastewater has been highly promoted. A typical use of the reclaimed water is for toilet flushing with about 970, 000 m^3/y. Reclaimed water criteria for use in toilet flushing were defined in the "Report on reuse of treated wastewater" among others for total coliforms (<1000 ml^{-1}) and BOD (<20 mg/L). In industrial countries like Germany and Japan, greywater is used for toilet flushing. This is justified based on the fact that the cumulative flow balance between the greywater generated and toilet flushing requirements shows a natural affinity at about 30% of the total water use.

On the other hand, in Western Australia, five particular methods were being tested by the Institute for Environmental Science at Murdoch University to achieve a fully integrated permaculture development **[11]**. Model guidelines for domestic greywater reuse in Australia have also been prepared, covering hand basin toilets, primary greywater systems (direct subsurface application) and secondary greywater systems (mesh, membrane or sand filtration). For the primary systems, the guidelines adopted the Californian approach of requiring the use of a surge tank with a screen to remove lint and hair.

2.2 RELATED WORKS

A study was reviewed from Hamilton, *et. al.*, 2007 **[12]** revealed that was RIRA (Recycled Water Irrigation Risk Assessment) structured in a general RIRA outlines by selecting one of the following pathogens in the risk analysis: poliovirus, rotavirus, hepatitis A virus, adenovirus and many others. RIRA was a decision support tool that has been developed for conducting quantitative risk assessment models of microbial risks in recycled water schemes.

In Canada, the problem of attributing risk to time-varying dose patterns was considered. Classically, risk assessments in this case were handled using an average dose obtained by dividing the total exposure, which may have occurred in a very short time, by the duration of the study. However, this does not recognize that the susceptibility of organisms may vary during a lifetime. An example Murdoch, *et al.*, 1998 **[13]** was shown based on the Armitage-Doll multistage model for carcinogenesis and the aim was to estimate roughly the impact of using an unweighted, rather than a weighted, dose average.

In Australia, data from the Ames screening bioassay was considered. This method was used in data analysis from IPCS (International Programme on Chemical Safety), a collaborative study of the potentially mutagenic effects of various compounds and mixtures from sink and toilet tubs **[14]**. The method permitted the elimination of cytotoxic effects; it provided a summary measure of potency; and it enabled well-known and powerful statistical methods to be used in the analysis of an experiment with a complicated design for greywater reuse.

2.2.1 Environmental and Health Problems

The reuse of greywater is playing an important role and also efficient use of water resource. Moreover, public concerns about public health and environmental issues will need to be addressed. Greywater reuse in spite of well recognized, it brings a lot of adverse effects either in environmental or human health.

2.2.2 Human health

If men do not expose directly to the greywater and it will not cause any problem to human body. But it is important factor caused the bad impact to human health, if they eat or intake any vegetable and fruit from the garden which is watering with greywater.

2.2.3 Environmental Healths

i) Plants

The maximum trace elements tend to accumulate in plants and soil, which could result of phytotoxicity in plants. The excessive nutrients of growing period may be detrimental to many

plants, causing excessive vegetative growth, delayed or uneven maturity, and even reduced plants quality.

ii) Soils

The effect of surfactants on decrease capillary rise in loses or soils. The sodium toxicity discuss above, another indirect effect of high sodium content is the deterioration of the physical condition of soil

iii) Groundwater

High contaminant loads from these sources accumulate within the area resulting in widespread contamination. Rapid water quality following rains potentially follows from leaching, adsorption and macrospore flow.

iv) Water Bodies

The hazardous contamination in groundwater from soil will encounter surface runoff as the groundwater level above the water table when raining heavily within a long period which has hazardous content will flow into the nearest water bodies.

2.3 REVIEW ANALYSIS

Review on risk assessment for greywater reuse. The below table is the summary of risk assessment implementation in other country.

Review	Method of Risk Assessment	Effectiveness (Finding or result)
Nicholas,Ashbolt 2007 (Australia) [15]	Environmental Microbiology and Pathogen Risk Assessment,	Provide key information for pathogen budgeting
Hamilton, A.J., Stagnitta, F., Kumarage, S.C., Premier,., R.R., 2007 (Australia) [12]	Recycled Water Irrigation Risk Assessment (RIRA)	Determine the probability of infection
Friedrich-Karl, 1996 (Marquardstr, German) [16]	Microbiological	Identify the hazardous organism and its risk
Murdoch and Krewski, 1998 (Canada) [13]	Armitage-Doll	Estimate the impact of using an unweighted rather than a weighted, dose-average
Krewski, *et al.*, 1993; Claxton, *et*	Ames Screening bioassay	Elimination of cytotoxicity for

al., 1992; Margolin, *et al.*, 1981 (Australia) [17]		complicated greywater treatment system design

The studies were reviewed on existing researches from year 1981 until recent year 2007. Even there were some outdated review, but there were two recent researches in year 2007 which was considered a new approach. There were two similar risk assessment methods that measured the same hazardous matter. Environmental Microbiology and Pathogen Risk Assessment and Microbiological were used to assess Enteric Viruses. In each method of risk assessment the hazardous matter measured were different and contribute different result. The existing study was not applicable in our country since factors influenced such as demographic, culture habit and geographic condition drive to unique characteristics of greywater in our country.

2.4 CONCLUSION

The summary of the risk assessment method indicates that to the respond hazardous problem, the method of risk assessment was identified. A suitable environmental health risk assessment for greywater reuse in household was proposed which is Microbiological Risk Assessment. This risk assessment method is applicable and fulfills the goals of the study. The study is concluding success because both goals of the study are achieved.

Suggestions for the greywater reuse application:

1. The steps of greywater treatment need to improve especially on disinfection part. In the disinfection part, extra chemical matters are required to add in. It can not function well if only with the present of chlorine.

2. Sand filtration must change to a more advanced filtration because the sand filtration is not sufficient to filtrate the contaminations such as oil, chemical and biological constituents.

3. The only septic tank is not enough for grease separation. Two to three septic tanks is suggested to be added to ease the process of decomposition and separation.

4. Always refer to the objective of the study, to ensure that the information collected is tally with the title.

2.5 REFERENCES

[1] Dixon, A. (1999). "Water Saving Potential of Domestic Water Reuse Systems Using Greywater and Rain Water in Combination." Department of Civil and Environmental Engineering, Imperial College London UK.

[2] Ottoson and Stenstrom (2002). "Microbial Risk Assessment And Its Implications For Risk Management In Urban Water System." Lintoping University , The Temu Institute, Department of Water and Environment

[3] Al-Jayyousi, 2003; "Review of Different Treatment Systems For Households Or Neighbourhoods." Swiss Federal Institute of Aquatic Science and Technology, Dunbendoft, Switzerland.

[4] Suhaimi, A.T., Junaidah, A. and Bahardin, B (2002). "River Protection: Alternative Approaches to Pollution Control." Ingenieur Bulletin, The Board of Engineers Malaysia, Vol. 17, Dec. 2002.

[5] Raja Datuk Zaharaton, R.Z.A., (2005). "Water Services Agenda in the Ninth Plan" Water Malaysia Issue No:10 (August 2005)

[6] Chan, N.W. (2005). "Using Tariffs and Water Demand Management For Sustainable Water Resources Management: Examples from Malaysia". (http://www.waterwatchpenang.org)

[7] Chan, N.W. (2002). "A Critical Review of Malaysia's Accomplishments on Water Resources Management Under Agenda 21. In Jamaluddin Md. Jahi, Mohd. Jailani Mohd. Nor, Kamaruzzaman Sopian, Ismail Sahid and Abdul Hadi Harman Shah (Eds) Realising Agenda 21: Proceedings International Conf. on Environmental Management : Ten Years After Rio. Environmental Management Programme, Centre for Graduate Studies, University Kebangsaan Malaysia, Bangi, 315-334.

[8] Mustow, S.R., Smerdon, T., Pinney, C., Wagget, R. (1997). "Water Conservation-Implication of Using Recycled Greywater and Stored Rainwater in the UK." Final Report 13134/1, prepared by Building Services Research and Information Association for UK Drinking Water Inspectorate.

[9] Asano, T (1996). "Wastewater Reclamation and Reuse." Technomic Publishing, Lancaster, PA.

[10] Hildebrand, R (1999). "Sedimentationsanlage Hilderbrand. In Grauwasser recycling, Schriftenreline fbr", 5, pg. 51-60.

[11] Anda, M., Ho H., Matthew. K, and Monk K (1996). "Greywater Reuse Option:Areas For Further Research in Australia." Envir. Res. Forum, 3-4, Transtec, Switzerland, p. 347.

[12] Hamilton, A.J., Stagnitti, F., Kumarage, S.C., Premier, R.R.(2007). "RIRA: A Tool Conducting Health Risk Assessments For Irrigation of Edible Crops With Recycled Water." Faculty of Land and Food Resources, The University of Melbourne, Australia. Research Institute for the Green World.

[13] Murdoch, D. and Krewski, D. (1998). "Carcinogenic Risk Assessment With Time-Dependent Exposure Patterns." Risk Analysis, 8:521-530.

[14] Claxton, S (1992). "Type of Disturbance and Ecological Historical Determine Structural Stability."

[15] Ashbolt, N (2007). "Environmental Microbiology and Pathogen Risk Assessment." The University of New South Wales, Sydney, Australia.

[16] Fiedral - Karl (1996). "Preconcentration of Trace Metals on Nanoparticles for Time-Resolved Measurement." Hong Kong University Thesis Online.

[17] Krewski, D (1993). "Priorities And Progress Under The Great Lakes Water Quality Agreement." New South Wales State of the Environment.

CHAPTER 3

GREYWATER QUALITY IN PARIT RAJA RESIDENTIAL AREA, MALAYSIA

Abstract

Sullage (grey-water) is one of the major point pollution sources, which is discharged from residential and commercial areas into the rivers without any treatment. The study conducted mainly to determine the quality, flow pattern of local sullage and to compare the significant portion with the Interim Water Quality Standards (INWQS). Sullage has created a doubt upon its release to water body, considering that sullage has neither physical nor characteristics evidence describing about its quality and effect. Sampling was done for two different seasons which are dry and wet season, besides considering to a different time and day respectively. Almost all of the parameter results derived has showed a common significance that is, the quality of sullage produced everyday merely is a polluted substance. Mean Dissolved Oxygen (DO) for all day recorded DO as low as 1.84 mg/L, whereas the DO should be around 3 to 5 mg/L to be considered as safe. While mean value for flowrate, BOD, TS, pH and turbidity are 0.00572 m^3/s, 43.98 mg/L, 275.67 mg/L, 7.98 and 46.69 NTU respectively. Factors affecting the results would be the rate of activity occurred, household patterns on water consumption and the existence of time of comfortable condition for residences at respective period. Results achieved indicate that sullage would be classified in Class V where this type of water is much polluted and has no function for any usage purpose. Next, from this result the corresponding authority should spare efforts for treating sullage. Wholly, the rationale of this study has given the opportunities for researchers to understand and further to extend this study according to right and refurbished approach.

Keywords: *Sullage, Greywater, Residential area*

3.0 INTRODUCTION

Malaysia owned net of river stream which are mass and unique. This gifted rivers plays an important parts in our environmental system, furthermore it also contribute and significant to our nations development and beauty in a way that had been traditional and common. For long, Malaysia's government is in serious effort to preserve and conserve our river, realizing that this heritage is our responsibility. In conjunction with our country's rapid progress, the rivers are forced to pay the price of development.

Now, rivers are not clean anymore and polluted. They are filled with numerous kind of pollutant contributed by many sources especially from industrial, residences and agricultural. Basically, river stream in urban areas received high volume of pollutants compared to the more rural area. This is because pollutants are produced higher in urban.

From residences aspects, sullage is the main 'product' of pollutant produce by society everyday. Sullage is discharged without any treatment and thereafter it caused questions on what are the impact of sullage to the environment especially to water and stream river. Until now, there is no detailed study or statement regarding reference has been done to determine the characteristics of sullage produced from residential area in Malaysia (Azni, *et al.*, 2004).

3.1 PROBLEM STATEMENT

Parit Raja town located in the district of Batu Pahat, becoming a fast developing town powered by the presence of Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO) day by days. This situation indirectly fertilizes the development of new residential area to cope with the need of KUiTTHO students. The development of new residential areas is so rapid and this town is packed with residential area compare to other types of building or construction.

Because more residential areas means more pollutants will be produced, it arise and worsen the problem of residential waste especially sullage. Clearly, physical analysis of the water is crucial. The quality of sullage can help define the guidelines needed to reduce health risks from exposure

(Marilyn, 2002). It is important to come with information that will conclude the characteristics of this greywater to implement the proper treatment of wastewater.

3.2 OBJECTIVES

1. To identify the quality of sullage from the residential area;
2. To study the flow pattern of sullage;
3. To compare the significance of sullage based on Malaysian Environmental Quality Act – EQA 1979 and INWQS.

3.3 SCOPE OF STUDY

The study will be conduct at the selected residential area in Parit Raja. For this purpose, Taman Pintas Jaya is chosen as the study area. It consists of houses located in the boundary of this residential area as to conclude the situation of sullage studied. The sullage that will be monitored is absolutely just from this specific area.

3.4 METHODOLOGY

The methodology that will be adopted in this thesis writing is a combination of research, field observations and laboratory analysis. The outcome of these methods will be use to conclude this research. Upon that, the outcome will act as the guideline and fact of greywater assess in the study area. These combinations are made because methods contained will able writer to collect and grant sufficient information regarding greywater.

3.4.1 Research

First stage of research's progress comprise of research that is the most important method in order to define and to understand what the real sullage is. This process was done time by time and with the co-operations of many parts. Research should be in manners of discussing, granting information, finding sources and a little bit of interviews. Discussions are made with advisor to determine the definition of sullage and scope that will be covered in this research. Primary information is based on library besides personnel's and organization's required information. Sources of information can be widen and broad with secondary source that are journals,

researches, work paper, thesis, assessment and many. There will be interview when it is needed where methods before could not give sufficient.

3.4.2 Field observation

Most of the information needed expected to be granted by this method, which is field observation. Field observation will comprise of analytical measurement such as flow of sullage, quantity of sullage produced, current situation of study case (Taman Pintas Jaya) and others.

3.4.3 Sampling

Sampling (grab sampling) of sullage were done in this method, after background of drainage, depth, width and supportive information taken. Grab sampling is a water sampling use to represent a situation which the quality of wastewater will change randomly or in case where wastewater quality change found in the sampling period (Ray, 1992). Wastewater sample will be taken for a long period for every interval. By using this method of sampling, value of average can be provided from the whole value.

Sampling session conducted had covered three sampling point of the study area as in **Figure 1** (Apendix). Sampling will be done in certain period and time that is important and crucial to the production of sullage. For this purpose, samples are to be taken for one working day, one Saturday and one Sunday to study the possible variation in sullage quantity and quality. Samples were preserved and followed by analysis, according to the standard method for each parameter taken.

3.4.4 Laboratory analysis

Among needed test are the Biochemical Oxygen Demand (BOD) test, Total Solid (TS) test and measurement of Dissolved Oxygen (DO) and pH.

BOD is the amount of oxygen used by bacteria to oxidize organic pollutant, especially the nitrogenous materials. Usually BOD test is done at 20°C temperature for 5 days. Basically, BOD is done by incubating wastewater sample in a tighten bottle and kept in the incubator (that is dark) for certain period of days, normally 5 days. The dissolved oxygen for the sample will be measured before and after the incubation, dissolved oxygen will decreased and this quantity is the BOD measure of the sample.

Generally the total solids can be described as residue after heating process at between 103° C and 105° C. Materials that vanished by this process is not called as solids. Total solids even can be divided into Suspended solids and Dissolved solids.

Dissolved oxygen is needed to generate a healthy and quality aquatic life. Oxygen are dissolved plenty in waters, about 14 mg/L at 0°C and 7.5 mg/L at 30°C. Nowadays, measurement of dissolved oxygen is done fast and accurate, normally by using the DO meter. For pH, the step is the same for measuring DO that is by using the pH meter.

3.5 RESULTS AND DISCUSSION

Two part of data attained from study area are hydraulic data and water quality data. Sampling is done for wet season and dry season, the data and results are then divided into time of sampling. This is done in order to able us to see the pattern and behavior of the sullage.

Results achieved is mainly related to contributing factors such as number of person contributing, time of clock, season, activities involved, purposed of water consumption and many. These factors are generally difficult to be determined specifically and yet these are the main portions of sullage and supposed to be study together.

Previous study also indicates that pollutants concentration in sullage may vary from time to time, day to day and season to season.

Value obtained for each criterion taken care was presence from the residential area as its characteristics and sullage collected from other type of housing area (e.g. apartment, low cost, and condominium) may show difference in quality and of course it's contributing factors.

3.5.1 Hydraulic results

Hydraulic data for this purpose comprise of flow rate of sullage which originate from the calculation of velocity and the area of sullage respectively. Flow rate is recorded in order to identify which time and day respectively play significant part in sullage characteristics of Taman Pintas Jaya.

The flow pattern of sullage according to respective clock time is described in **Figure 3.1**. Mean flow rate for all sampling are 0.00572 m^3/s. Clock time evidence indicates that by middle of the day, flow of sullage is produced maximally. This scene possibly is the outcome of increased activities involved; possibly residences prefer to cook and wash by the time.

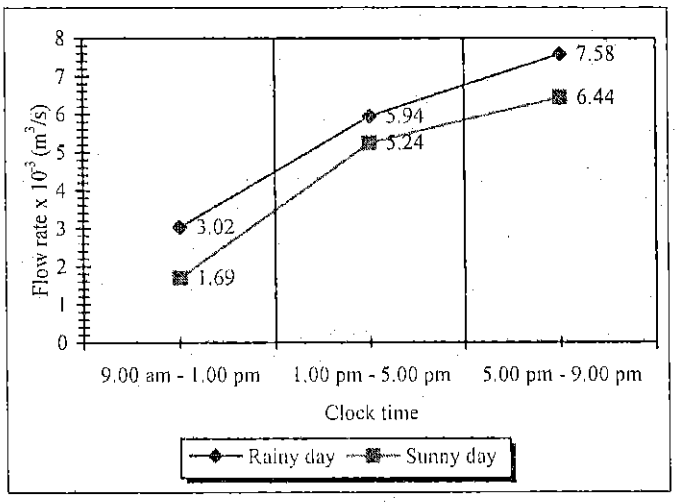

Figure 3.1: Flow rate versus clock time

The flow pattern of sullage according to respective day and season are described in **Figure 3.2**. Through the week, sullage produced increased before reaching peak by Sunday.

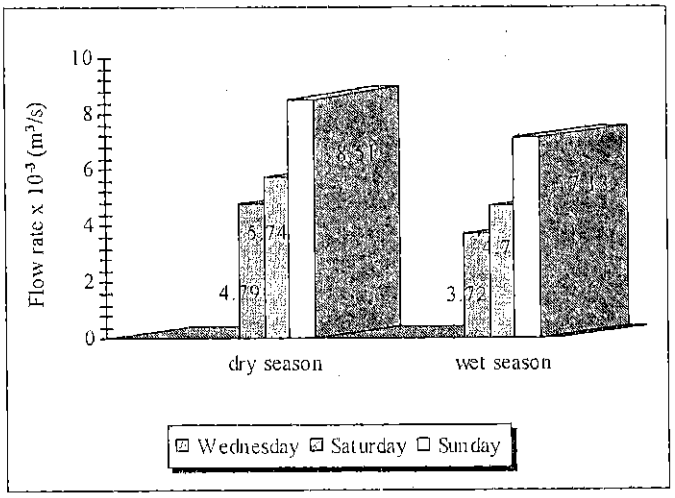

Figure 3.2: Variation of flow rate for all sampling day

Predicted cause is residences would prefer or having more time to do their activities on weekend holiday, considering that the residential area is majority occupied by factory workers and students.

Another characteristic that can be seen from previous sampling session is that flow rate is higher on dry season comparing to wet season. In this case we can see that residences are comfortable to do their activities in houses on a sunny and clear day comparing to a rainy and cloudy day.

3.5.2 Greywater quality

Four chosen parameter for greywater quality have been analyzed and the results of these parameter (pollutants) can be taken as guidance to evaluate the strength of pollution and they are BOD, TS, DO, pH and turbidity. **Figure 3.3** shows the variation of common pollutants versus clock time.

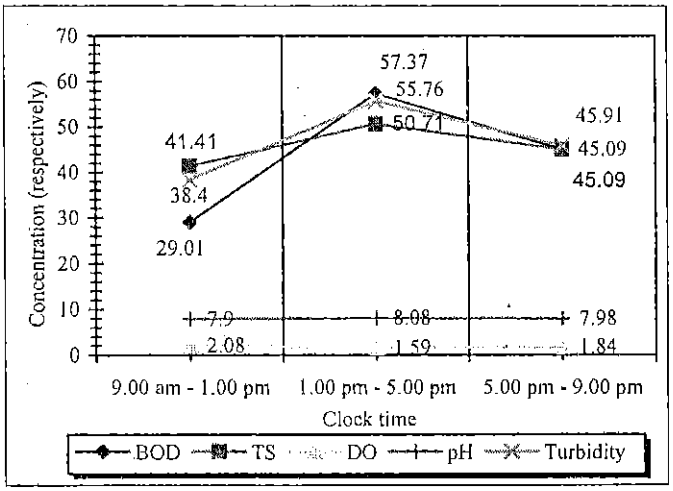

Figure 3.3: Variation of common pollutants versus clock time

Sullage quality has been obtained where mean value for parameters taken care in this study are BOD, TS, DO and pH. BOD values are 46.43mg/L for dry and 41.86 mg/L for wet season. Both TS values for dry and wet season are 47.97 mg/L and 43.42 mg/L. DO values are 1.69 for dry and 1.97 mg/L for wet season. Both pH values for dry and wet season are pH 8.04 and pH 7.92. All of the value obtained for each parameter is significantly related to activity occurred at certain period of time.